VII.2 Hydrogen Codes and Standards

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International Code Council (ICC), Chicago, IL
National Fire Protection Association (NFPA), Quincy, MA
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Start Date: 1995
Projected End Date: Project continuation and direction determined annually by DOE

Objectives

- Facilitate creation and adoption of model building codes and equipment standards for hydrogen systems in commercial, residential, and transportation applications.
- Coordinate and conduct research and development (R&D) needed to establish sound technical requirements for standards, codes, and regulations for hydrogen components and systems.
- Provide technical resources to harmonize development of international standards among the International Organization for Standardization (ISO), International Electrotechnical Commission (IEC), and Working Party on Pollution and Energy (GRPE).

Technical Barriers

This project addresses the following key technical barriers from the Codes and Standards section (3.6.4.2) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Limited Government Influence on Model Codes

(B) Competition among Standard Development Organizations (SDO) and Model Code Development Organizations (CDO)

(D) Large Number of Local Government Jurisdictions (approximately 44,000)

(F) Limited DOE Role in the Development of International Standards

(G) Inadequate Representation at International Forums

(I) Conflicts between Domestic and International Standards

(J) Lack of National Consensus on Codes and Standards

(K) Lack of Sustained Domestic Industry Support at International Technical Committees

(M) Jurisdictional Legacy Issues

(P) Large Footprint Requirements for Hydrogen Fueling Stations

Technical Approach

- Support and facilitate the timely and efficient incorporation of hydrogen safety issues into existing and proposed codes and/or standards promulgated by organizations such as the ICC, NFPA, Society of Automotive Engineers (SAE), and ISO.
- Support and encourage technical and operational consistency among and across the codes and standards developed by different organizations.
- Identify critical gaps and deficiencies in codes and standards and formulate recommendations to address them.
- Develop a unified national agenda and help support consistent representation of technical experts from industry and government at key global venues.
- Work with key agencies and industry in other countries to harmonize standards, codes, and regulations in all major market areas for hydrogen technologies.
- Develop preliminary near-term specifications for hydrogen fuel quality for proton exchange membrane (PEM) fuel cells in road vehicles through ISO TC197 Working Group 12.
- Develop collaborative, international R&D and testing plan to obtain data needed to advance preliminary technical specification for fuel quality to an international standard.

- Initiate R&D for an integrated engineering systems approach to hydrogen safety.
- Initiate R&D for component testing, focusing on gaseous hydrogen containers and hydrogen fueling stations.

Accomplishments

- National templates for standards, codes, and regulations for hydrogen vehicles and facilities, and for on-site hydrogen generation and stationary and portable fuel cells accepted by major SDOs in the U.S., FreedomCAR and Fuel Partnership (FCFP), key industry associations, and many state and local governments as guideposts for coordinated development of standards and model codes.
- National templates incorporated in Codes and Standards RD&D Roadmap of FCFP.
- NREL continued to support development of key standards to implement national templates:
  - **American National Standards Institute (ANSI):** ANSI modified its *National Resource for Global Standards* to include the *Hydrogen and Fuel Cells Codes and Standards Portal* (http://hcsp.ansi.org): a web-based database and search engine for hydrogen and fuel-cell-related codes and standards of participating CDOs and SDOs (e.g., NFPA, ICC, ASME). The Hydrogen and Fuel Cell Codes and Standards Matrix and Database, which catalogs and tracks national and international codes and standards in the development process, was integrated into the Hydrogen Portal and linked to the Hydrogen and Fuel Cell Safety Report.
  - **American Society of Mechanical Engineers (ASME):** ASME prepared a technical report, *Hydrogen Standardization Interim Report for Tanks, Piping, and Pipelines*. The report provides a technical basis for a standard for high-pressure hydrogen stationary, transportable, and portable tanks and for a standard addressing the use of non-steel metals and composite materials for high-pressure hydrogen storage tanks. ASME prepared a second technical report, *Design Margin Guidelines for High-Pressure Composite Hydrogen Tanks* to address safety factors in composite storage tanks. ASME also initiated development of ASME B31.12, which will provide recommendations for design criteria and materials for high-pressure piping in hydrogen service.
  - **Compressed Gas Association (CGA):** CGA, administrator for the U.S. Technical Advisory Group (TAG) of ISO TC197, refined a web site to manage TAG activity, including accessing drafts of documents, accessing comments, and voting.
  - **CSA America:** CSA America is developing standards for hydrogen fueling systems. CSA America is also developing a process through which requirements included in initial drafts of these standards can be made more performance-based and, where appropriate, harmonized with the requirements of the Federal Motor Vehicle Safety Standards.
  - **International Code Council (ICC):** The ICC Ad Hoc Committee for Hydrogen Gas (AHCHG) completed development of new hydrogen safety requirements (and modifications to existing requirements) for incorporation in the 2006 editions of the *International Building Code*, *International Fire Code,* and *International Fuel Gas Code.* With the 2005 Code Development Hearings, the AHCHG completed its work and was disbanded by the ICC.
  - **National Fire Protection Association (NFPA):** NFPA completed revision cycles for NFPA 52*, Vehicular Fuel Systems 2005 Edition*, and NFPA 55*, Standard for the Storage, Use and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders and Tanks 2005 Edition*. NFPA also initiated revision cycles for NFPA 484*, Standard for Combustible Metals, Metal Powders and Metal Dusts 2002 Edition,* which provides the opportunity to include metal hydride storage containers, and NFPA 853, Stationary Fuel Cell Power Plants 2003 Edition. In addition, the NFPA Standards Council approved consolidating all the hydrogen safety requirements in its various codes and standards into a single document, tentatively to be entitled NFPA 2, *Hydrogen Technology*.
- The ICC, NFPA, and National Hydrogen Association (NHA) formed a Hydrogen Industry Panel on Codes (HIPOC) to provide a neutral forum to develop and submit hydrogen-related code provisions to both the ICC and the NFPA. The HIPOC will play a key role in harmonizing provisions in ICC and NFPA codes and standards. The HIPOC formulated new hydrogen-related safety requirements for consideration at the 2006 ICC Code Development Hearings.
- Continued (with U.S. Fuel Cell Council and NHA) to support a single national committee, the National

Hydrogen and Fuel Cells Codes and Standards Coordinating Committee (NHFC4), to consolidate hydrogen and fuel cell codes and standards coordination.

- NREL reached agreement with NHA to expand the scope of the Hydrogen Safety Report to serve as the principal vehicle of communication for the NHFC4.
- Continued to explore collaborative R&D among the United States, Japan, and the European Union on hydrogen safety, codes, and standards.
- Led U.S. and Canadian team of experts from industry, government, and academia to establish an agreement with Japan and the European Union on the development of hydrogen fuel quality specifications for PEM fuel cell road vehicles under ISO.
- Coordinated DOE efforts to establish a unified international R&D program to obtain data needed to create an international standard based on modifications to the ISO technical specification for hydrogen fuel quality, including baseline fuel quality testing at the University of Hawaii with single-cell test hardware and expertise from General Motors, UTC Fuel Cells, and Ballard Power Systems.
- Worked with the Codes and Standards Tech Team of the FCFP to revise its R&D Roadmap and to coordinate efforts on R&D for fuel quality, integrated safety engineering, risk assessment, and detection and mitigation of hydrogen hazards.
- Participated in the peer review of the Codes and Standards Tech Team by the National Academy of Sciences (NAS).
- Conducted and hosted (with Sandia National Laboratories) a second workshop to address risk assessment activities, methodologies, and data requirements in conjunction with IEA Annex 19, Hydrogen Safety.

Introduction

The development and promulgation of codes and standards are essential for establishing a market-receptive environment for hydrogen-based products and systems and, in turn, for hydrogen to become a significant energy carrier and fuel. With the help of key stakeholders, the DOE Hydrogen, Fuel Cells, and Infrastructure Technologies (HFCIT) Program and NREL are coordinating a collaborative national effort to prepare, review, and promulgate hydrogen codes and standards needed to expedite hydrogen infrastructure development.

The DOE Hydrogen Codes and Standards Program facilitates the creation and adoption of model building codes and equipment standards for hydrogen systems in commercial, residential, and transportation applications and provides technical resources to harmonize the development of international standards. NREL continues to coordinate and provide overall management of domestic codes and standards activities on behalf of DOE and the FCFP Codes and Standards Tech Team. NREL also helps DOE and the Tech Team create a unified agenda for hydrogen standards, codes, and regulations that will enable the United States to present an industry and government consensus position at critical international negotiations on global hydrogen standards and regulations.

Approach

The federal government has an indirect and relatively limited role in the voluntary consensus process through which codes and standards are developed in the United States (Barrier A). Because of the importance of establishing a harmonized set of standards on which model codes and regulations can be based, DOE, primarily through NREL, has devoted considerable effort to facilitating and coordinating this consensus process.

NREL helps DOE and the FCFP Codes and Standards Tech Team implement the R&D Roadmap by coordinating and conducting R&D needed to establish sound technical requirements for standards, codes, and regulations for hydrogen components and systems. Key R&D areas supported by NREL include integrated engineering approaches to hydrogen safety and comprehensive R&D and testing to develop data for international hydrogen fuel quality standards.

Results

Key results in domestic codes and standards are summarized in Table 1.

TABLE 1. Key Results in Domestic Codes and Standards

Standard, Model Code	Organization	Status	Finish Date	Comment
Infrastructure				
Gaseous storage, transport and portable tanks	ASME	Interim report: Pt. 1 - Review of existing reference standards Interim report: Pt. 2 - Study of existing data, standards, and materials	May 05	Appropriate design requirements, up to 15,000 psi
Piping and pipelines	ASME	Interim report: Pt. 3 - Study of existing data, standards, and materials	May 05	Design margins in ASME B31, 49CFR 192 to 15,000 psi
Dispensing systems	CSA (HGV 4.1)	Draft standard completed	In review	
Hoses	CSA (HGV 4.2)	Draft standard completed	In review	
Temp. compensation devises	CSA (HGV 4.3)	Draft standard completed	In review	
Breakaway devices	CSA (HGV 4.4)	Draft standard completed	In review	
Priority/sequencing	CSA (HGV 4.5)	Draft standard completed	In review	
Manually operated valves	CSA (HGV 4.6)	Draft standard completed	In review	
Automatic high pressure valves	CSA (HGV 4.7)	Draft standard completed	In review	
H2 Fueled Vehicles				
Pressure relief devices	CSA	Draft standard completed (PRD1/HPRD1)	In review	Combined with PRD1
Interface				
Fuel specification for PEMFC vehicles	ISO TC197	Draft Technical Specification (TS14687-2) in review	Jun 06	Harmonized with SAE J2719
Fuel specification for PEMFC vehicles	SAE	Technical Information Report (TIR J2719) published	Aug 05	Harmonized with ISO TS14687-2
Fuel specification for stationary systems	CGA	Revision of existing standard	TBD	Work deferred pending ISO, SAE guidelines
Weights and measures	NIST	Draft standard for hydrogen gas metering	In review	NIST handbooks 44 and 112
Gas and vapor detector/sensor	UL	Standard (UL 2075) published	Nov 04	Toxic/flammable gas detection
Built Environment				
Fueling station	ICC	Provisions for underground LH_2 storage, gaseous canopy storage adopted	June 05	2006 editions fire, fuel gas codes
Hydrogen production rooms	ICC	Adopted in 2003 edition	Oct 05	Residential, mechanical codes
Vehicular fuel systems	NFPA 52	2005 edition published	Aug 05	CNG/LNG, GH/LH
Gaseous, liquid fuel storage/handling	NFPA 55	2005 edition published	Aug 05	Combines 50A/50B
Building construction safety code	NFPA 5000	New edition	2006	Refers to NFPA 52/55
Stationary, Portable Fuel Cells				
Fuel cells for telecommunications	UL	Draft standard (UL 2266) in review	TBD	EM compatibility, electrical safety
Hand-transportable fuel cells	UL	Draft standard (2265) in development	TBD	Disposable methanol cartridges
Gaseous hydrogen generators	UL	UL2264B (electrolyzers) in review, UL2264A (water reaction) and UL2264C (reformers) in development	TBD	Involves CSA, ISO
Fuel cells for industrial trucks	UL	Draft standard (UL2267) in development	TBD	Forklifts, tugs
Other				
Hydrogen Portal	ANSI	1st rollout 7-20-04	1st version, 6-15-05	Electronic access to standards
ISO TC197 USTAG website	CGA	Operational	Aug 05	Post information, voting

Conclusions and Future Directions

NREL will continue to support the development and promulgation of hydrogen codes and standards by:

- Implementing the national templates for hydrogen codes and standards.
- Building the NHFC4 to consolidate domestic and international codes and standards activities.
- Coordinating and conducting R&D based on the Codes and Standards Tech Team Roadmap.
- Initiating R&D collaboration with Asia and Europe on hydrogen safety, codes, and standards, beginning with hydrogen fuel quality.
- Coordinating the participation and input of U.S. and Canadian industry in developing a technical specification for hydrogen fuel quality under ISO.

FY 2006 Publications/Presentations

1. Presentation and paper, *The Department of Energy's Hydrogen Safety, Codes and Standards Program: Status Report on the National Templates*, SAE 2006 World Congress.

2. Presentation on codes and standards at HFCIT Merit Review.

3. Presentation and paper, *U.S. DOE's Hydrogen Codes and Standards Activities*, World Hydrogen Energy Conference 16.

4. Presentation on fuel quality R&D/testing plan to ISO TC197 WG12.

5. Presentation on national templates to National Hydrogen and Fuel Cells Codes and Standards Coordinating Committee.

6. Presentations on DOE/NREL hydrogen codes and standards activities to Savannah River National Laboratory and Johnson Matthey.

7. Co-editor, Material Research Society Symposium Proceedings, vol. 885, *The Hydrogen Cycle–Generation, Storage and Fuel Cells.*

8. Author, Hydrogen energy cycle: An overview, pp 3167 – 3179, *Journal of Materials Research,* Vol. 20, No. 12, December 2005 (special focus issue on energy and the environment).